SEPTEMBER 2019 Update

5G Millimeter Wave Forecast Update

Major changes to the forecast over the last three months include:

1. We've received some contradictory information about the deployment of mm-wave radio units. Component vendors report high numbers, suggesting the equivalent of 100,000 gNodeB radio units during 2019. But the system level OEMs report much lower numbers, limited by the operators' ability to get legal access to poles on the street. We have chosen to keep a lower total of 48,000 RUs in our forecast for this quarter, but our followers should note that there's activity that could lead to a surge of higher levels of deployment.

2. The T-Mobile / Sprint merger has made positive progress, although it's still delayed by state legal actions that oppose the federal government decisions. Our forecast now assumes that the merger will close, and that T-Mobile and Sprint will focus their energy on deployment in the 2.5 GHz range, with only minimal investment in the mm-wave bands until about 2023.

3. The Japanese deployment plans submitted to the Japanese government during the spectrum licensing process appear to still be valid. Most deployment in the near term for the 2020 Olympics relates to 3-4 GHz bands, but some 30,000 gNodeB units are estimated for the 2020 Olympics. We have inserted additional units into our Japan forecast accordingly, and adjusted our regional splits for 2019 and 2020.

4. Table 1-4 was included in this forecast to track the distinctions between high power gNodeB units (above +53 dBm EIRP) and lower power units (below +53 dBmi, which corresponds to deployment in stadiums or subway stations where higher power would be detrimental.) This quarter, we have adjusted the profile to show our expectation for about half of the Japanese deployment to be 'indoor', in subways and stadiums)

5. We've adjusted our profile of 64T, 256T, and 1024T configurations to correspond with higher numbers of 'indoor' units and fewer 1024T units in the high power application. This tentative breakdown is likely to change as the operators learn about the number of beams and beamwidth that will be optimal in their networks.

6. We're hearing about a lot of design-in activity for mm-wave radios in smartphones by almost all handset vendors. We're still skeptical about the consumer uptake of the mm-wave smartphone, and we're keeping our chips on the promotion of mobile hotspots instead. We've adjusted the number of mobile devices upward to include 9 million devices in 2020 based on the limited coverage of the USA and Japanese networks, but growing to over150 million mobile devices in 2025. Current design-in activity is consistent with supporting rapid

growth, but we have limited the sales based on poor performance so far and limited network coverage.

7. We've adjusted our expectations for regional shipments of user devices, based on the large commitment for networks in Japan. We believe that Japanese operators will start to incentivize customers to use mm-wave devices, increasing our optimism for hotspots and possibly smartphones.